SECTION 7. POINT SOURCES, COMBINED SEWER OVERFLOWS, WATER WITHDRAWS, AND ON-SITE WASTE DISPOSAL SYSTEMS

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SECTION 7. POINT SOURCES, COMBINED SEWER OVERFLOWS, WATER WITHDRAWS, AND ON-SITE WASTE DISPOSAL SYSTEMS

7.1 Introduction

This section describes development of the point source input for the Phase 5.3 Model including a description of the data sources, methods, and assumptions. It also documents combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), on-site wastewater disposal systems (OSWDS), and water withdraws for water supply or other consumptive uses.

The Phase 5.3 Watershed Model point source database includes information for about 815 significant industrial, municipal, and federal facilities discharging directly to the surface waters in the Chesapeake Bay watershed. The exact number of operational dischargers changes from year to year as new facilities are added and old facilities closed. Dischargers from portions of the Chesapeake Bay watershed in New York, Pennsylvania, and West Virginia, as well as Maryland, Delaware, Virginia, and the District of Columbia in their entirety are included in the Phase 5.3 point source data. For each facility outfall, the database includes monthly flow and monthly average concentrations for total nitrogen (TN), ammonia (NH_3), nitrate and nitrite (NO_3+NO_2), total organic nitrogen (TON), total phosphorus (TP), orthophosphate (PO_4), total organic phosphorus (TOP), total suspended solids (TSS), biological oxygen demand (BOD_5), and dissolved oxygen (DO). The point source data cover the 1984 to 2005 time frame and is updated annually as data becomes available. The record of point source discharges for the Phase 5.3 domain outside the Chesapeake watershed were generated by the Richmond USGS using the same decision rules as the point sources within the Chesapeake watershed, and the data extends from 1984 to 2003 only.

In the Phase 5.3 Watershed Model, the river segments are simulated as a completely mixed reactor and all the point source loads within a reach are summed for each of the 1,063 river segments and input as a daily load.

The complete time series of information on point source discharges as applied in the Phase 5.3 river-segments from 1985 to 2005 are in the Chesapeake Community Modeling Program's (CCMP's) Phase 5.3 data library at http://ches.communitymodeling.org/models/CBPhase5/datalibrary.php.

7.2 Point Source Flows and Loads

From 1984 to 2005, point source flows have increased overall throughout the Chesapeake watershed (Figure 7-1). In contrast, point source loads have generally decreased because of increased point source management and controls. Figure 7-2 shows the decrease in total Chesapeake point source nitrogen and phosphorus loads. Flow for the eight major basins is shown in Figures 7-3, and equivalent plots are shown for the nitrogen and phosphorus loads in Figures 7-4 and 7-5. Monthly data parameters of the point source database are listed in Table 7-1.

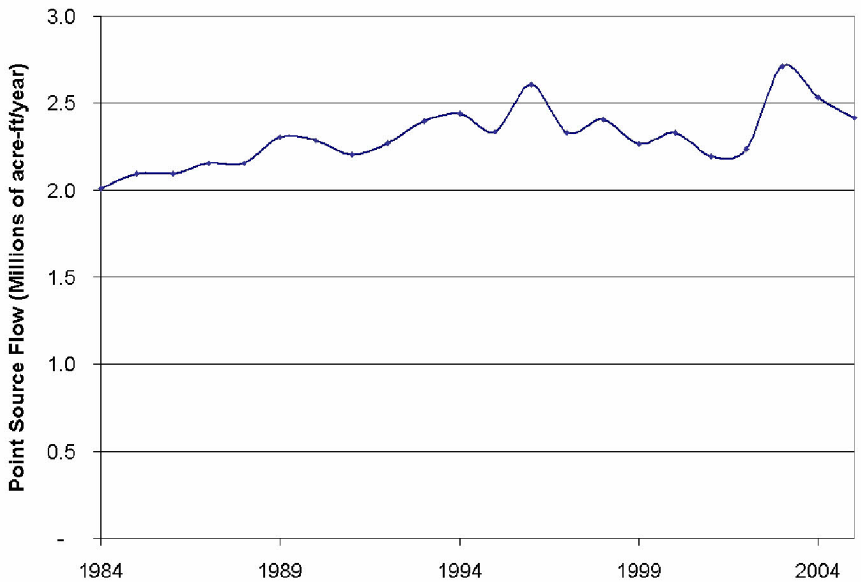


Figure 7-1. Point source flow.

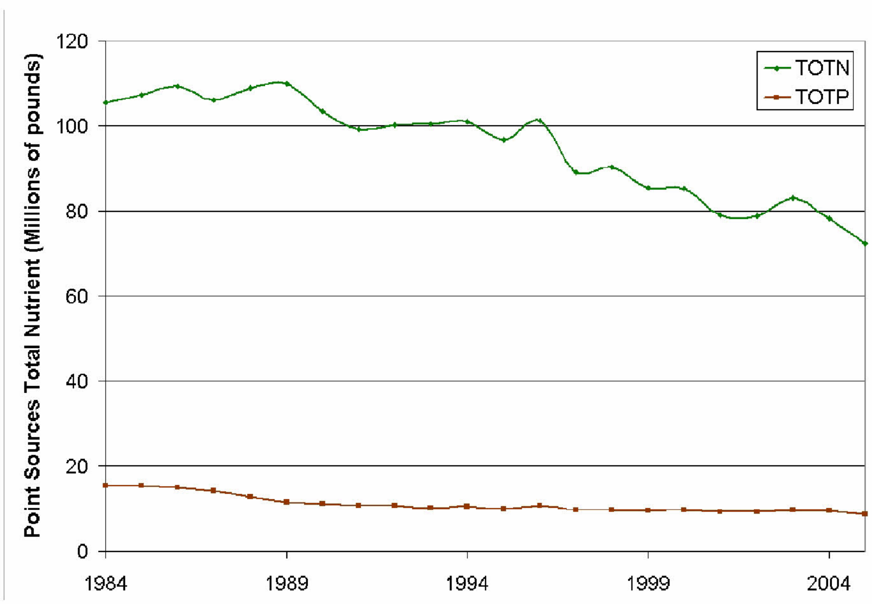


Figure 7-2. Point source total nitrogen (green) and total phosphorus (red) loadings.

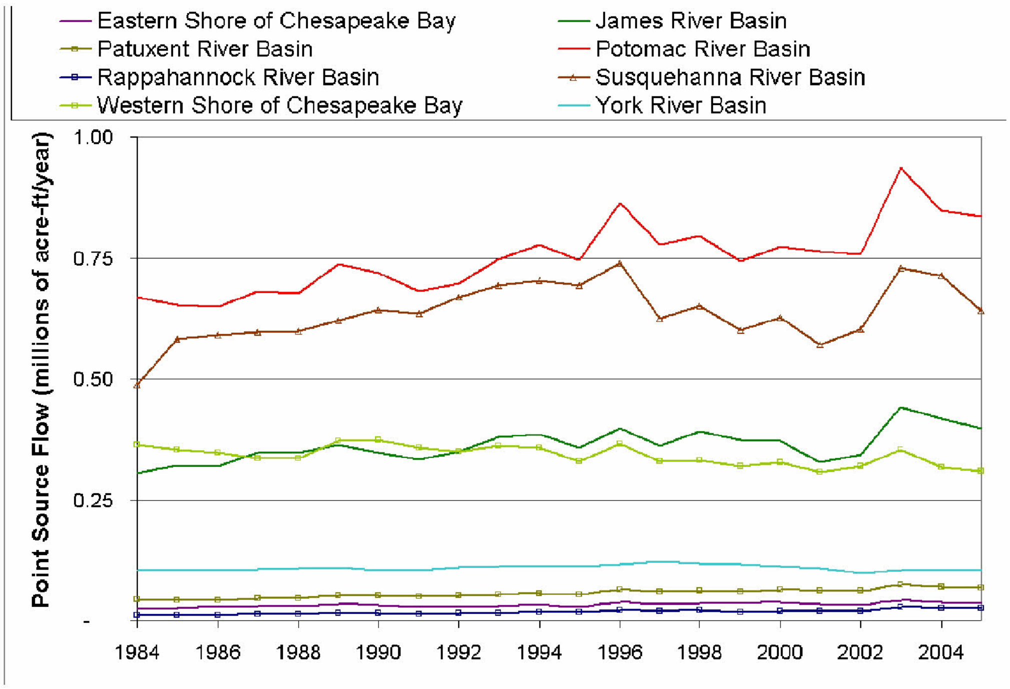


Figure 7-3. Chesapeake Bay eight major basins point source flow.

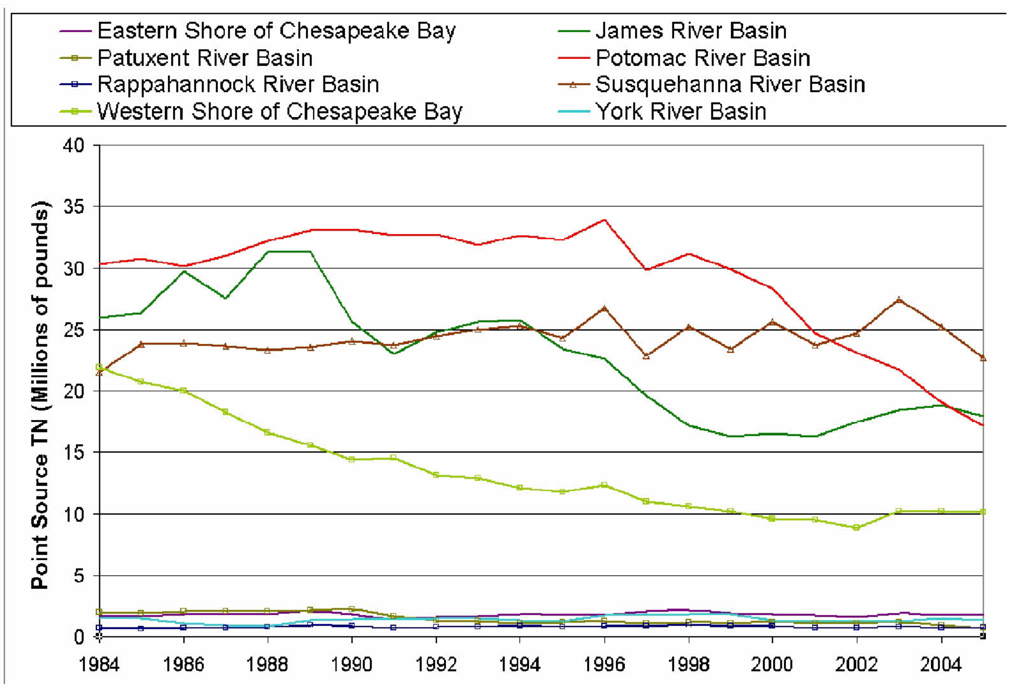


Figure 7-4. Chesapeake Bay eight major basin's total nitrogen load.

Table 7-1. Parameters included in the point source database.

Parameter	Units	
	Database	Phase 5.3 input
Flow	Million gallons per day (mgd)	Million gallons per day (mgd)
Total Nitrogen (TN)	mg/l	lbs/day
Ammonia Nitrogen (NH_3)	mg/l	lbs/day
Nitrate-Nitrite Nitrogen ($NO_{2,3}$)	mg/l	lbs/day
Total Organic Nitrogen (TON)	mg/l	lbs/day
Total Kjeldahl Nitrogen (TKN)	mg/l	lbs/day
Total Phosphorus (TP)	mg/l	lbs/day
Phosphate (PO_4)	mg/l	lbs/day
Total Organic Phosphorus (TOP)	mg/l	lbs/day
Biochemical Oxygen Demand (BOD_5)	mg/l	lbs/day
Dissolved Oxygen (DO)	mg/l	lbs/day
Total Suspended Solid (TSS)	mg/l	lbs/day

On the basis of minimum flow rates, significant and nonsignificant municipal and industrial dischargers were grouped separately in the early 1990s by each jurisdiction. Those two groups of significant and nonsignificant dischargers are the basis for differences in annual progress reporting in the CBP.

Note: The term *nonsignificant* is defined by a minimum flow and does not imply any quantification of importance to water quality. To avoid confusion over the term, the acronym NSF for NonSignificant Facilities will be used in text that follows.

Almost all NSF information was incorporated into the Phase 5.3 point source input files. However, the information on NSFs is generally not as well characterized as the significant dischargers. Most of the NSFs' load estimates were developed through a special study of such loads in 2008.

7.2.1 Significant and NSF Dischargers

A significant discharger, also called a major discharger, is a facility that meets *one* of the following criteria:

- In West Virginia, Delaware, and New York—a facility treating domestic wastewater and the design flow is greater than or equal to 0.4 mgd
- In Pennsylvania—a facility treating domestic wastewater and discharging greater than or equal to 0.4 mgd
- In Maryland—a facility treating domestic wastewater and the design flow is greater than or equal to 0.5 mgd
- In Virginia—a facility treating domestic wastewater and the existing design flow is greater than or equal to 0.5 mgd west of the fall line or 0.1 mgd east of the fall line

as well as all new facilities greater than 40,000 gallons per day (gpd) or facilities expanding by greater than 40,000 gpd as significant)

- Industrial facilities with a nutrient load equivalent to 3,800 TP lbs/year or 27,000 TN lbs/year
- Any other municipal and industrial wastewater facilities identified within a jurisdictional tributary strategy

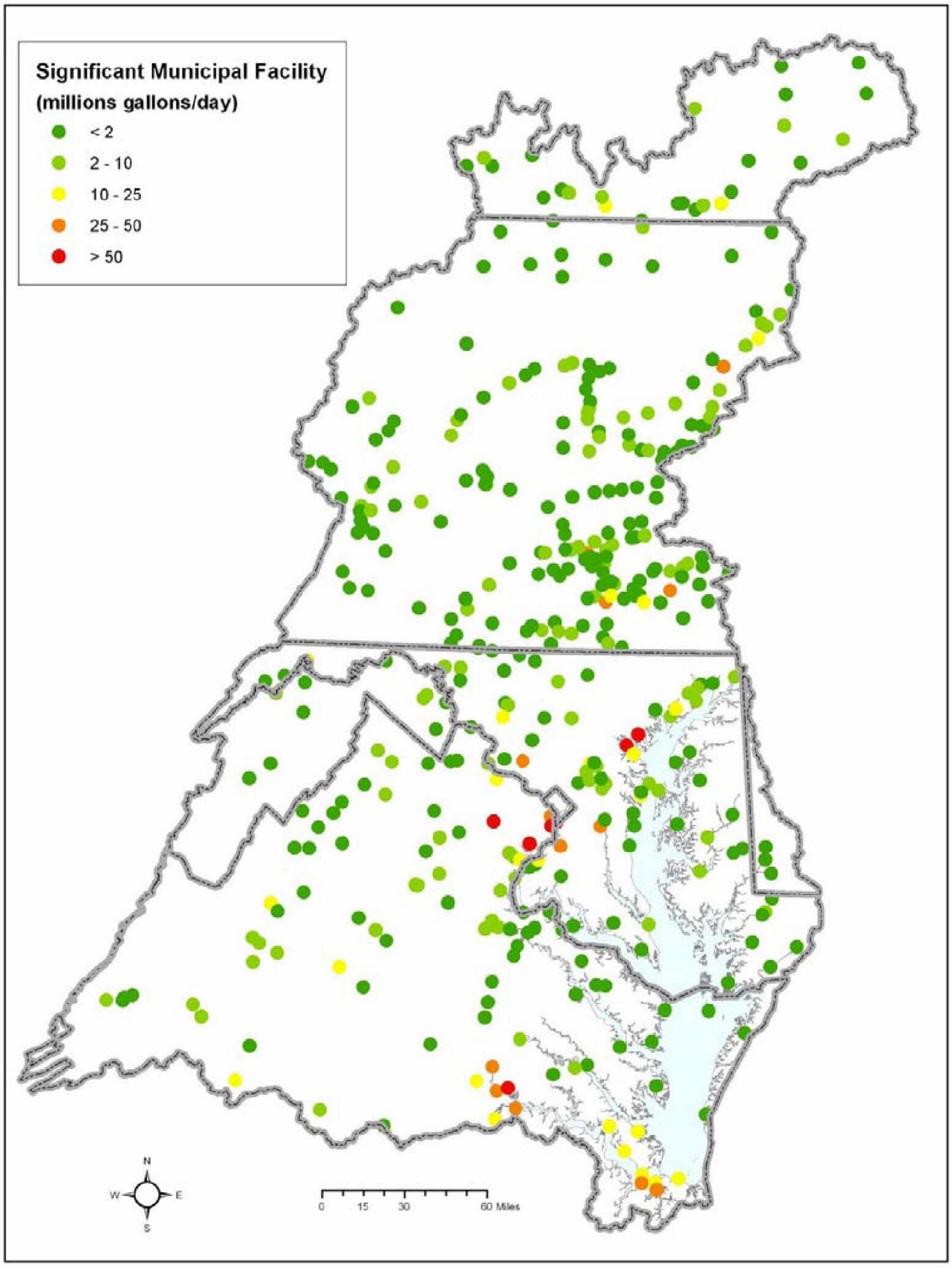
Table 7-2 summarizes the number of current, active significant facilities in each jurisdiction. There are 478 significant facilities reported in the database.

Table 7-2. Nutrient permit tracking summary under the Basinwide National Pollutant Discharge Elimination System Wastewater Permitting Approach, through June 2010

Jurisdiction	Significant facilities	Permits drafted	Permits issued	Design flow of facilities permits issued	Percent of design flow for permits issued/sig. facilities
DC	1	1	1	152.5	100%
DE	4	4	4	3.3	100%
MD	87	72	51	357.7	42%
NY	28	1	1	20.0	22%
PA	213	141	103	434.1	67%
VA	125	124	124	1,253.5	100%
WV	20	21	21	38.5	81%
Total	478	364	305	2,259.7	74%

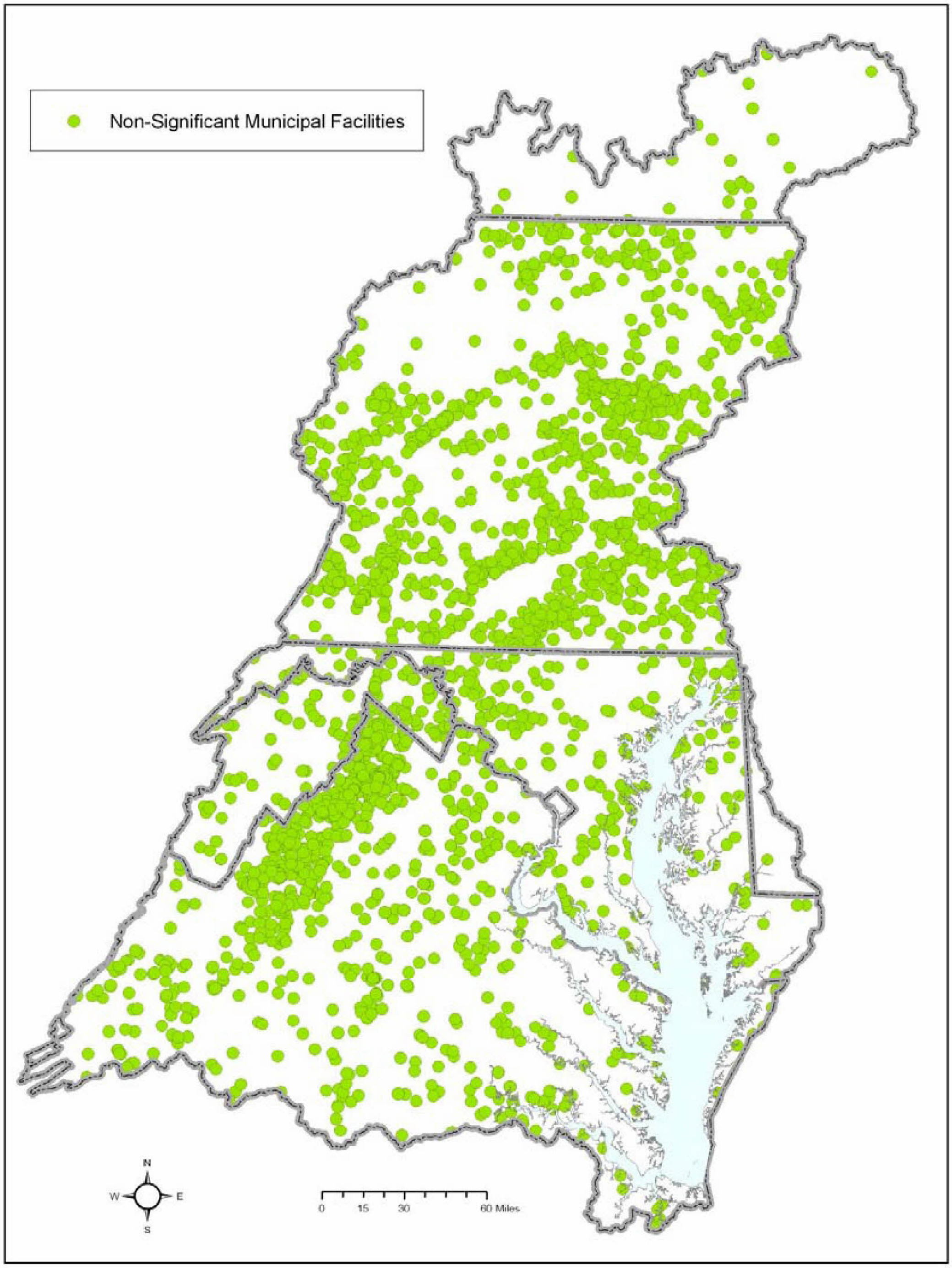
Source: USEPA Region 3, Region 2

Note: Some industrial design flows are not available or not comparable and not listed in the database. Some permits can contain compliance schedules.



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 7-5. Significant municipal wastewater treatment facilities in the Chesapeake Bay watershed.



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 7-6. Nonsignificant municipal wastewater treatment facilities in the Chesapeake Bay watershed.

In addition to pollutant and flow parameters, listed in Table 7-1, descriptive information about each facility including information such as facility name, National Pollutant Discharge Elimination System (NPDES) permit number, location (county, state, and basin), and facility type (industrial, municipal, or federal) are tabulated in the following database http://ches.communitymodeling.org/models/CBPhase5/datalibrary/model-input.php.

Table 7-3. Municipal wastewater facilities by jurisdiction as of June 2010

Jurisdiction	Significant	Nonsignificant
DC	1	1
DE	3	1
MD	75	163
NY	26	26
PA	183	1,246
VA	101	1,618
WV	13	125
Total	**402**	**3,180**

Source: EPA Region 3

Note: Blue Plains wastewater treatment plant serves DC and portions of Maryland and Virginia but is counted once in this table as a DC plant.

Table 7-3, Table 7-4, and Table 7-5 summarize Phase 5.3 Model municipal wastewater flow and nutrient loading estimates by jurisdiction and major river basin, respectively. Modeled sediment loads for those facilities are not presented because wastewater discharging facilities represent a *de minimis* source of sediment (i.e., less than 0.5 percent of the 2009 total sediment load). In 2009 municipal wastewater treatment facilities contributed an estimated 17 percent of the total nitrogen and 16 percent of the total phosphorus loads delivered to Chesapeake Bay.

Table 7-4. Model estimated 2009 municipal wastewater loads by jurisdiction delivered to Chesapeake Bay

Jurisdiction	Flow (mgd)	Total nitrogen delivered (lb/yr)	Total phosphorus delivered (lb/yr)
DC	140	2,387,918	20,456
DE	2	42,529	4,984
MD	563	11,928,717	568,905
NY	62	1,360,684	159,096
PA	335	9,391,741	740,397
VA	585	16,926,806	1,047,998
WV	13	188,137	62,674
Total	1,698	42,226,535	2,604,509

Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Table 7-5. Model estimated 2009 municipal wastewater loads by major river basin delivered to Chesapeake Bay

Basin	Flow (mgd)	Total nitrogen delivered (lbs/yr)	Total phosphorus delivered (lbs/yr)
Susquehanna River	383	10,556,831	835,426
MD Eastern Shore	25	696,872	70,540
MD Western Shore	254	7,279,406	331,362
Patuxent River	58	640,507	61,948
Potomac River	635	9,475,644	412,464
Rappahannock River	23	376,453	46,463
York River	20	691,550	45,012
James River	299	12,494,335	798,615
VA Eastern Shore	< 1	14,937	2,679
Total	1,698	42,226,535	2,604,509

Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

7.2.2 Data Sources

The sources of point source information include the following:

- EPA's Permit Compliance System (PCS), based on state NPDES Discharge Monitoring Reports (DMRs)
- Data files from Pennsylvania Department of Environmental Protection including a 1994 sampling study data and the Pennsylvania Voluntary Monitoring data since 1998
- Data files from the Virginia Department of Environmental Quality based on PCS, DMRs, and the Virginia Voluntary Nutrient Monitoring Program
- Data files from the Metropolitan Washington Council of Governments (MWCOG)
- Combined sewer overflow flow and concentration estimates from DC's Department of the Environment
- The final tributary strategies from Pennsylvania, Maryland, DC, and Virginia
- Data from the Maryland Department of the Environment
- Data from Delaware Department of Natural Resources and Environmental Control
- Data from West Virginia Department of Environmental Protection
- Data from New York Department of Environmental Conservation

Data source information is documented in USEPA (1998, 2000). Because of a lack of data format consistency among the data received from the jurisdictions and PCS, extensive data compiling was required.

7.2.3 Current Point Source Data Reporting Requirements

As described in the *Data Submission Specifications and Requirements* (USEPA 2006), for data submitted for Phase 5.3 Watershed Model point source database, jurisdictions are required to submit monthly concentration and flow data for all parameters listed below for significant discharges.

1. At Facility Level: Data must be provided for those municipal, industrial, and federal facilities as defined above as *significant dischargers* of TN and TP to the Chesapeake Bay watershed. The jurisdictions must annually update their list of significant dischargers with additional facilities that meet one of the criteria of the significant facility definition. The location (county, latitude/longitude) of each facility's *discharge* point must be reported.

2. At the Monthly Level: *12 individual months* of concentration and flow data for the nine identified parameters must be provided for each outfall. Jurisdictions must submit all parameters in each month's data record for each facility. They must submit data for the following parameters: average monthly flows and average monthly concentrations of NH_3, TKN, NO_2+NO_3, TN, PO_4, TP, BOD_5 ($CBOD_5$ is preferred), and DO. All nitrogen species must be reported as nitrogen; all phosphorus species must be reported as phosphorus.

If no monthly monitored concentration data exist for one or more of the nine parameters for a facility, the jurisdiction submits the default concentration data or calculated data on the basis the species relationship listed in Table 7-6. All default or calculated data are flagged with explanatory information. Industrial facility data are reported as average monthly flow and concentrations. A flow diagram of the point source nutrient data processing is shown in Figure 7-7.

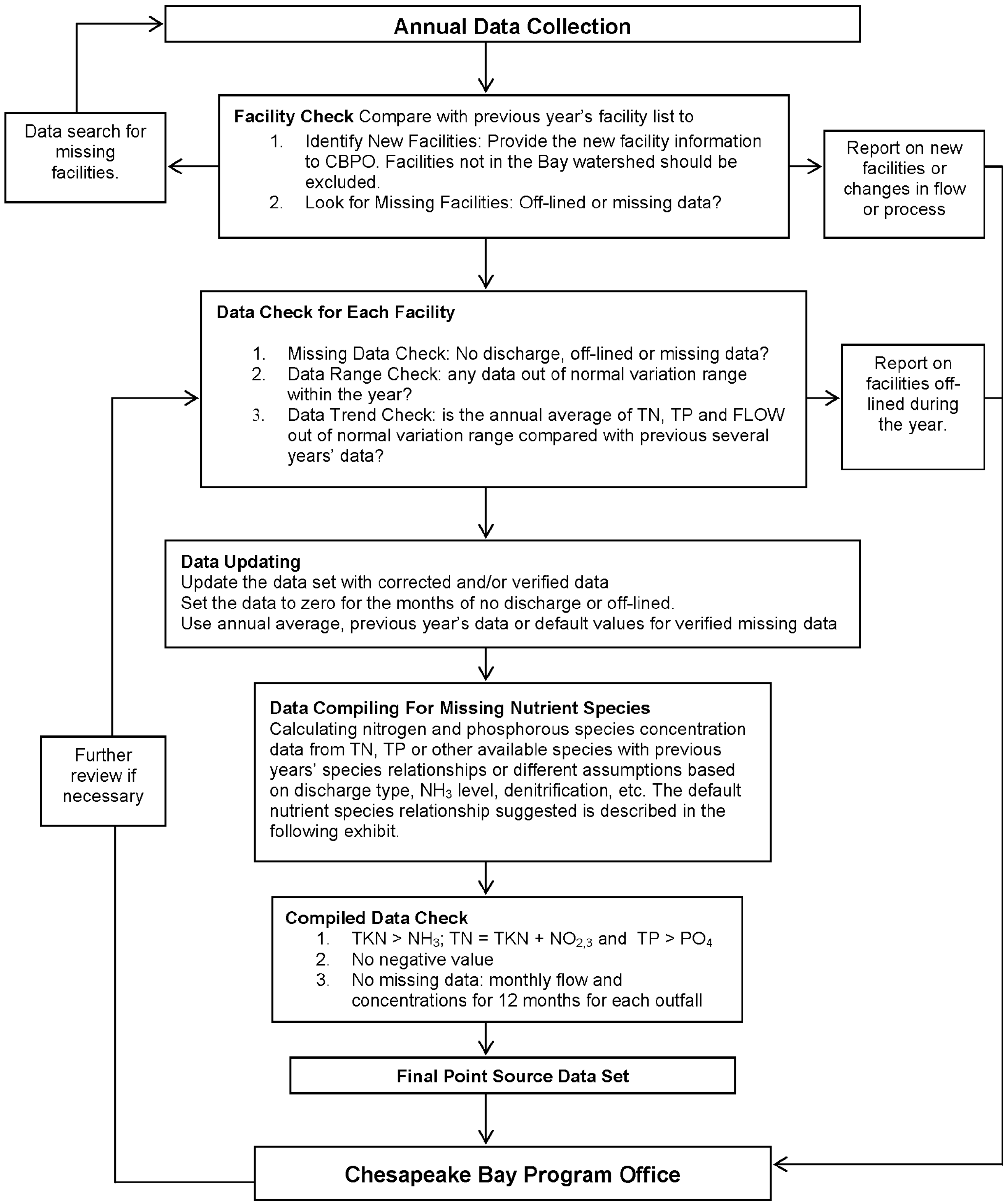


Figure 7-7 Point source nutrient data processing flow diagram.

7.2.4 Nutrient Species Defaults

The nutrient species calculation must be done for any data record for which nutrient species data were insufficient or missing (Table 7-6).

Table 7-6. Nutrient species default relationships for point source data

Type of point source		$NH_3/NO_{2,3}$/OrgN[a] (w/o nitrification)	$NH_3/NO_{2,3}$/OrgN (w/ nitrification)[c]	$NH_3/NO_{2,3}$/OrgN (w/ denitrification)
Municipalities		80/3/17[b]	7/80/13[b]	12/73/15
Industries	Chemical	7/85/8+		
	Pulp & Paper	1/0/99[b]		
	Poultry Facilities w/ BNR			8/75/17[b]
	Nonchemical (includes seafood, poultry, & food processors w/out BNR)[e]	80/3/17[b]	7/85/8[d]	8/75/17[b]

a. Organic nitrogen

b. Updated on the basis of an analysis of actual data from plants operating in Virginia.

c. Apply this relationship wherever NH_3 limits apply.

d. Assumed by performing an analysis of Maryland chemical industry wastewater effluents, which showed it is very close to the relationship for nitrifying sewage. This would apply to all chemical discharges and assumes that wastewaters are treated chemically and, thus, would not vary as for sewage relationships.

e. Biological nutrient removal

Type of point source	Facilities w/out TP reduction (PO_4/TOP ratio)	Facilities with TP reduction (PO_4/TOP ratio)
All	71/29[e]	67/33[e]

e. Determined by averaging the actual data from MD and VA plants (including Blue Plains for *with TP Reduction*. A facility with TP reduction is defined as a facility having a permit limit for TP.

Period	TSS default (all jurisdictions)	TSS default w/out NRT*	TSS default w/ NRT*
1985–1990[f]	45		
1990–2000	25		
2000–2010		15	8

* Nutrient reduction technology.

Type of point source	DO concentration 1985–1990	DO concentration 1990–2010
All	4.5 mg/l[f]	5.0 mg/l

f. The TSS and DO default numbers take into account a number of Nutrient Management Plan (NMP) facilities operating across the watershed from 1985-1990. In the early years of CBP nutrient reduction the state NMPs for POTWs focused primarily on phosphorus reductions.

7.2.5 Industrial Flow

Some point source industrial dischargers use river uptake as the only water source. As the facility both withdraws and discharges water in the same model segment, no flow discharge is assumed to come from these industrial facilities, only loads. Other industrial point source dischargers use city or well water, or a percentage of city or well water that makes up the total flow discharged. In such cases, the portion of the effluent from the city or well water source is included as a flow contribution to the river segment (Table 7-7). Other industrial plants not in the survey list were assumed to use 100 percent city or well water.

Industrial discharge facilities are facilities discharging process water, cooling water, and other contaminated waters from industrial or commercial sources (Table 7-10). EPA identified 1,679 NPDES permitted facilities discharging industrial wastewaters in the Chesapeake Bay watershed (Table 7-7), with 76 significant facilities (Figure 7-8) and 1,603 NSFs (Figure 7-9).

In 2009 industrial wastewater discharging facilities contributed an estimated 7.3 million pounds of the total nitrogen and 1.27 million pounds of the total phosphorus loads delivered to Chesapeake Bay, an estimated 3 percent and 8 percent, respectively, of all nitrogen and phosphorus loads delivered to the Chesapeake Bay (Tables 7-8 and 7-9).

Table 7-7. Industrial wastewater facilities.

Jurisdiction	Significant	Nonsignificant
DC	0	9
DE	1	1
MD	12	477
NY	2	45
PA	30	409
VA	24	639
WV	7	23
Total	76	1,603

Source: USEPA Region 3, Region 2

Table 7-8. 2009 Load estimates of industrial facility discharges.

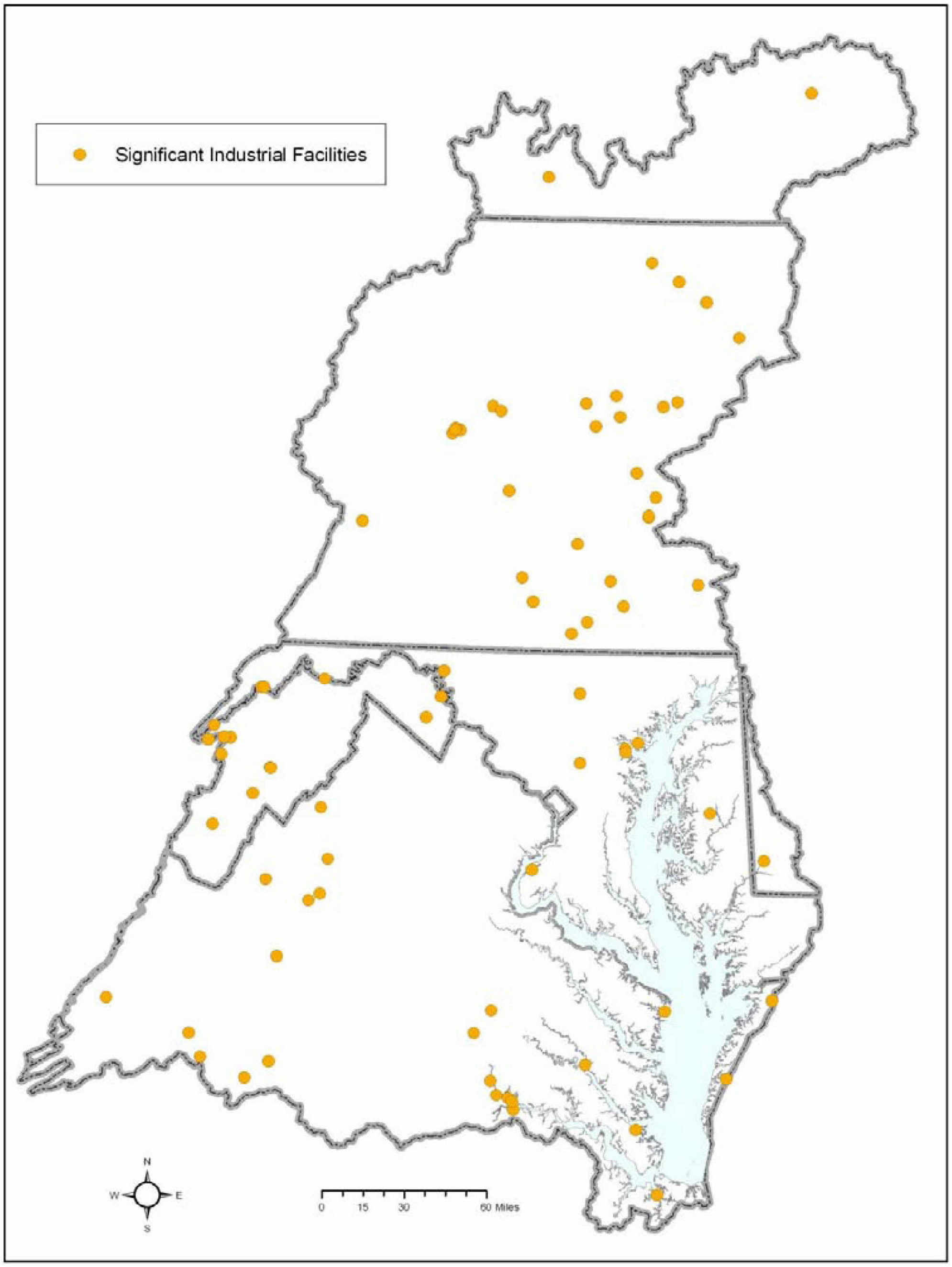
Jurisdiction	Flow (mgd)	Total Nitrogen Delivered (lbs/yr)	Total Phosphorus Delivered (lbs/yr)
DC	13	183,490	20,433
DE	< 1	95,438	71
MD	48	1,989,243	267,093
NY	7	126,897	19,971
PA	179	2,010,639	260,140
VA	160	2,883,828	649,266
WV	14	55,213	53,592
Total	422	7,344,748	1,270,566

Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Table 7-9. 2009 Flow, total nitrogen, and total phosphorus load estimates of industrial wastewater facility discharges by major river basin.

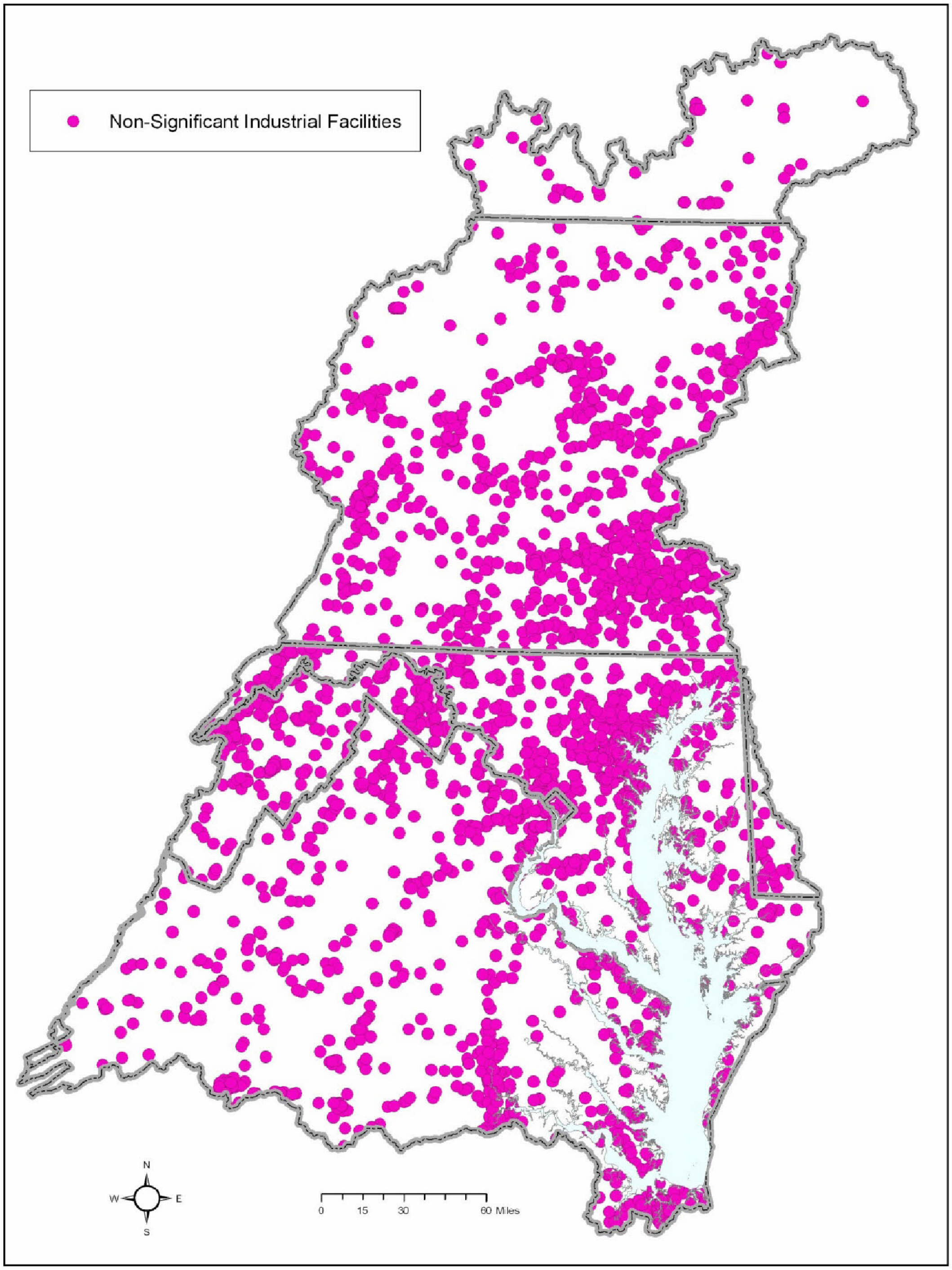
Basin	Flow (mgd)	Total nitrogen delivered (lbs/yr)	Total phosphorus delivered (lbs/yr)
Susquehanna River	184	2,171,197	281,922
MD Eastern Shore	5	302,210	45,626
MD Western Shore	21	1,369,383	105,100
Patuxent River	3	50,615	38,689
Potomac River	71	779,885	420,997
Rappahannock River	5	78,006	36,039
York River	81	478,892	81,675
James River	51	1,979,297	259,331
VA Eastern Shore	1	135,211	1,160
Total	422	7,344,697	1,270,539

Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 7-8. Significant industrial wastewater discharge facilities in the Chesapeake Bay watershed.



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario.

Figure 7-9. Nonsignificant industrial wastewater discharge facilities in the Chesapeake Bay watershed.

Table 7-10. Sources of industrial water withdrawal based on survey results

State	Facility	NPDES	2003 Flow (mgd)	Water source distribution: River water (%)	Water source distribution: City or well water (%)
DE	Invista (Dupont-Seaford)	DE0000035	30.73	99.95	0.05
MD	ISG Sparrows Point (Bethlehem Steel)	MD0001201	49.08		100
MD	Upper Potomac River Commission	MD0021687	20.47	100	0
MD	W R Grace	MD0000311	3.73		100
MD	Westvaco Corporation-Luke	MD0001422	1.54	100	0
NY	Pollio Dairy	NY0004308	0.86		100
NY	South Otselic State Fish Hatch	NY0244431	0.89		100
PA	Appleton Paper Springmill	PA0008265	4.39		100
PA	Empire Kosher Poultry-Mifflint	PA0007552	0.94		100
PA	Merck & Company	PA0008419	12.83		100
PA	Osram Sylvania Products, Inc.	PA0009024	0.83		100
PA	PA Fish & Boat Commission-Bellefonte	PA0040835	6.40		100
PA	PA Fish & Boat Commission-Benner Springs	PA0010553	6.00		100
PA	PA Fish & Boat Commission-Pleasant Gap	PA0010561	4.87		100
PA	PA Fish & Boat Commission-Typlersville	PA0112127	13.00		100
PA	P-H Glatfelter Company	PA0008869	12.00		100
PA	Pope & Talbot Wis Inc.	PA0007919	1.57		100
PA	Proctor & Gamble Paper Products	PA0008885	7.44		100
PA	USFW-Lamar National Fish Hatchery	PA0009857	4.40		100
VA	Brown & Williamson	VA0002780	0.83		100
VA	Coors Shenandoah Brewery	VA0073245	0.79		100
VA	Dupont-Spruance	VA0004669	23.96	100	0
VA	Dupont-Waynesboro	VA0002160	3.27		100
VA	George's Chicken Inc	VA0077402	1.27		100
VA	Georgia Pacific Corporation	VA0003026	6.25	100	0
VA	Giant Refinery-Yorktown	VA0003018	52.38		100
VA	Greif Bros Corp-Riverville	VA0006408	5.03	100	0
VA	Honeywell	VA0005291	117.64	95	5
VA	Merck -Stonewall Plant-Elkton	VA0002178	7.84		100
VA	Omega Protein Inc	VA0003867	2.55	100	0
VA	Phillip Morris-Park 500	VA0026557	2.14		100
VA	Pilgrim's Pride-Hinton	VA0002313	0.91		100

State	Facility	NPDES	2003 Flow (mgd)	Water source distribution: River water (%)	Water source distribution: City or well water (%)
VA	Smurfit Stone	VA0003115	18.61		100
VA	Tyson Foods, Inc.	VA0004031	0.97		100
VA	Tyson Foods, Inc.-Temperanceville	VA0004049	1.06		100
VA	Westvaco Corporation-Covington Hall	VA0003646	30.41	100	0
WV	Pilgrim's Pride	WV0005495	1.59		100
WV	Virginia Electric & Power	WV0005525	9.16	100	0

7.2.5.1 Process-Based Loads from Nonsignificant Industrial Dischargers

Process-based discharges from nonsignificant industrial facilities were also estimated. EPA's Integrated Compliance Information System (ICIS) database was queried for states that have migrated from EPA's PCS database (District of Columbia, Pennsylvania, and New York; Maryland facilities were obtained directly from Maryland Department of the Environment as a result of a pilot study). Facility data were obtained from EPA's PCS database for states that have not migrated to ICIS (Delaware, Virginia, West Virginia, and Maryland). The number of nonsignificant industrial facilities was reduced by removing facilities with Standard Industrial Classification (SIC) codes that do not have nutrients associated with the discharge, or whose loads are captured in the nonsignificant municipal discharger loadings. The SIC types that were removed are shown in Table 7-11.

The list of facilities was narrowed further by using latitude/longitude or county information to identify facilities outside the Chesapeake Bay watershed. Finally, facilities that were inactive during the model simulation period and a few years beyond (1985–2008) were also removed from the list of facilities.

DMR data from the population of facilities were used to derive loadings where available. Of the more than a thousand NSFs in the Chesapeake Bay watershed, only 85 facilities provided data for nutrients, and 400 provided flow data. For the remaining facilities, data from the Typical Pollutant Concentration appendix of the Improving Point Source Data for Reporting National Water Quality Indicators (Tetra Tech, Inc. 1999) was used to estimate pollutant loading.

Table 7-11. SIC codes not included in the list of nonsignificant industrial facilities

SIC Code	DESCRIPTION
4952	SEWERAGE SYSTEMS
4499	WATER TRANSPORTATION SERIVCES
4941	WATER SUPPLY
5812	EATING PLACES
6512	OPER OF NONRESIDENTIAL BLDGS
6513	OPERATORS OF APART BUILDINGS
6514	OPER OF DWELL OTHER THAN APART
6515	OPER OF RES MOBILE HOME SITES
6519	LESSORS OF REAL PROPERTY, NEC
6552	LAND SUBDIVIDERS & DEV, EX CEM
7011	HOTELS AND MOTELS
7032	SPORTING & RECREATIONAL CAMPS
7033	REC VEHICLE PARKS & CAMPSITES
7948	RACING, INCLUDING TRACK OPERA
7991	PHYSICAL FITNESS FACILITIES
8021	OUTPATIENT CARE FACILITIES
8051	SKILLED NURSING CARE FACILITIE
8052	INTERMEDIATE CARE FACILITIES
8062	GEN. MEDICAL/SURGICAL HOSPITAL
8063	PSYCHIATRIC HOSPITALS
8099	HEALTH & ALLIED SERVICES, NEC
8211	ELEMENTARY & SECONDARY SCHOOLS
8221	COLLEGES, UNIV & PROF SCHOOLS
8222	JUNIOR COLLEGES & TECH INSTITU
8299	SCHOOLS & EDUCATIONAL SERVICES
8322	INDIVIDUAL AND FAMILY SERVICES
8361	RESIDENTIAL CARE
8412	MUSEUMS AND ART GALLERIES
8661	RELIGIOUS ORGANIZATIONS
8999	SERVICES, NEC
9199	GENERAL GOVERNMENT, NEC
9223	CORRECTIONAL INSTITUTIONS
9512	LAND, MIN, WILDLIFE/FOREST CON
9621	REG & ADMIN OF TRANS PROGRAMS
9711	NATIONAL SECURITY

7.2.5.2 Nutrient Loads from Industrial Dischargers' Biocide Use

Nutrient loads resulting from the use of flue gas desulfurization units, effluent from coal ash ponds and biocide applications at high-flow facilities were estimated from available databases. Industrial facilities such as power plants, petroleum refineries, and steel mills were the focus of that evaluation. Data sets queried include EPA's PCS and ICIS permit systems, 316(b) cooling water intake structure regulation data, U.S. Department of Energy's Energy Information Administration data, and EPA's eGrid database.

Thirty-two power plants were identified in the Chesapeake Bay watershed. Eight of those facilities use cooling towers as part of their cooling system. Of those facilities, 18 use coal as a fuel source; 7 use a flue gas desulfurization, and 13 use ash ponds. Eighty-nine other industrial sites with cooling towers were identified in the watershed and represent a variety of industrial activities.

Cooling tower loads were estimated for eight facilities. The PCS and ICIS databases were queried for blowdown flows, and cooling tower chemical vendors were consulted to estimate water quality conditions in the towers. Facility use rates were then obtained from EPA's eGrid database to characterize utilization routines and variability in blowdown events. Flue gas desulfurization and ash pond loads were estimated using data obtained from the PCS and ICIS databases.

7.2.6 Combined Sewer Overflows (CSOs)

EPA relied on various sources of information to characterize the prevalence of CSOs in the Chesapeake Bay watershed and to quantify their loads for the Bay TMDL. In the Bay watershed are 64 CSO communities.

For four of the largest CSO communities in the watershed—Alexandria, Lynchburg Richmond, Virginia; and the District of Columbia—EPA relied heavily on readily available and relatively detailed Long-Term Control Plans (LTCPs) to characterize overflows. In addition, EPA ran simulations of existing sewer models for those communities to support developing overflow and water quality estimates. EPA used the District of Columbia's combined sewer system (CSS) model to develop loading estimates for the CSOs. For the Alexandria, Richmond, and Lynchburg CSSs, various versions of EPA's Storm Water Management Model (SWMM) were used to estimate overflows. CSO discharge monitoring data were available for the Alexandria and Richmond CSOs, but no samples were available from Lynchburg because the LTCP calls for complete separation of the system (i.e., separating the storm sewers from sanitary sewers).

Information related to loading from the other 60 CSO communities in the watershed includes spatial data collected as a result of a direct survey of the communities to support the TMDL, limited water quality and overflow data from some of the CSO communities in the watershed, and representative water quality concentrations available in the literature. Overflow volume and pollutant loading from CSO communities are heavily dependent on the service area or catchment area of the combined system. Service area data obtained from the communities were used to calculate the loading from each community during high-flow events. Precipitation data observations were also obtained from weather monitoring stations proximate to each community to derive runoff volumes. Overflows and associated pollutant loads from CSO communities were then developed using various sources of water quality data including monitoring data and literature values.

For the full list of CSO communities, see Table 7-18.

To avoid the difficulty of measuring LTCP implementation progress with weather-dominated CSO loading estimates, EPA used the 10-year average CSO loads for 1991–2000, which correlates with the hydrologic period selected for the TMDL.

7.2.6.1 District of Columbia CSOs

Data provided by the District of Columbia Department of the Environment was used for CSO flows and concentrations in the District of Columbia. Combined sewer overflow estimates were determined by simulating the combined sewer system (CSS) model developed by the District of Columbia Water and Sewer Authority (DCWASA) for the development of the Long Term Control Plan (LTCP) for DC CSOs (DCWASA 2002).

DCWASA maintains a MIKE URBAN H&H model to simulate its collection system. The model used the MOUSE hydrologic and hydraulic model engines to estimate overflows from CSO outfalls. For 1991–2005, CSO flows were based on model simulation of individual rainfall events. The model was not simulated for the period 1985–1990. The 1993 model simulated flows, which represented an average condition, were repeated for that period. Average concentrations were derived from the average EMC (event mean concentration) for CSO overflows taken from monitoring data collected for the LTCP. Those values are shown in Table 7-12. Figure 7-10 presents the time series TN and TP loads for DC CSOs.

Table 7-12. CSO water quality constituent EMCs developed by DCWASA (2002)

	EMCs (mg/L)					
Water quality constituent	**CSO 10**	**CSO 021**	**CSO 12**	**CSO 19 (location 1)**	**CSO 19 (location 2)**	**Outfall 001 (CSO bypass)**
TKN	6	3.8	4	4	2.4	17
NH_3-N	2.9	0.96	0.66	0.69	0.46	8.7
NO_3+NO_2-N	0.6	0.85	0.81	0.79	0.78	0.7
TP	1.31	1	0.98	0.85	0.83	2.4
DIP (PO_4)	0.37	1.04	0.11	0.23	0.15	0.8
TSS	147	130	186	96	182	130.1

Note: CSO 19 was monitored at two locations.

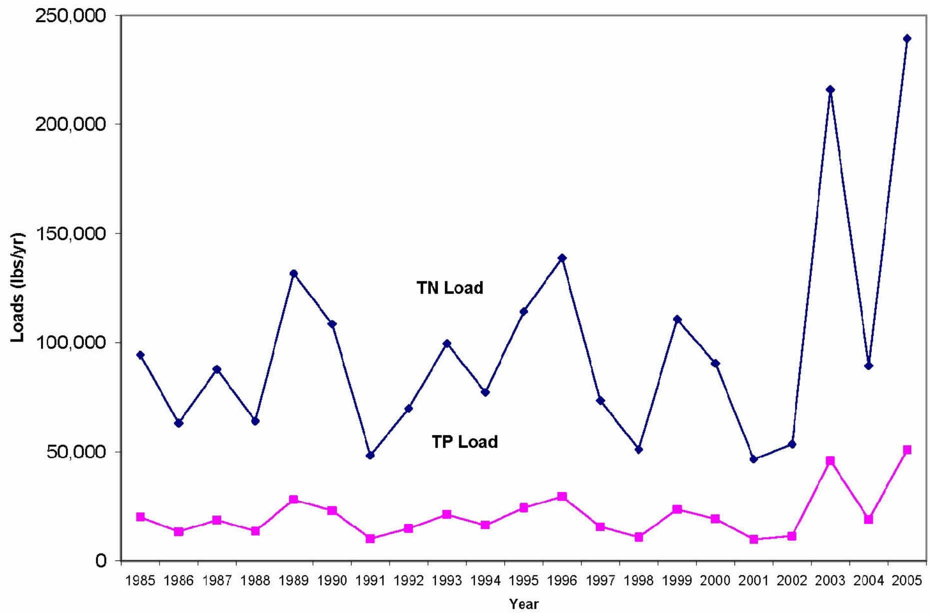


Figure 7-10. District of Columbia CSO loads for 1985–2005.

7.2.6.1 Other CSOs

Sixty-three additional CSO communities are in the Chesapeake Bay watershed outside the District of Columbia (Figure 7-14). Three of those are the larger communities of Alexandria, Lynchburg, and Richmond, Virginia, which were characterized in the first CSO characterization effort described above. The remaining 60 communities were characterized in a later effort.

First Round of CSO Characterization

In addition to DCWASA, overflows from three CSO communities were estimated as a part of the first round of CSO characterization. Those are the Virginia communities of Alexandria, Richmond, and Lynchburg. All three communities estimate CSO overflows using EPA's SWMM system. Alexandria and Richmond use the built-in RUNOFF module for hydrologic modeling on the basis of detailed service area information, and the TRANSPORT module for hydraulic modeling. For the purposes of the Phase 5.3 watershed model, the overflows calculated by SWMM for Alexandria and Richmond were directly input to the 5.3 Model.

The SWMM model developed for Lynchburg is circa 1989 (updated in 1995, 1998, 2000, and 2002) does not explicitly model real-time rainfall and hydrology. Instead, the model is used to regress current rainfall events with a range of calibrated events with known overflows. The Lynchburg overflow estimates were supplemented with data from a linear regression of rainfall to overflow volume, because that model is not a continuous simulation.

CSO discharge water has been monitored in the Alexandria and Richmond CSOs, but no samples are available from Lynchburg because the Long Term Control Plan (LTCP) calls for complete separation of the system. Table 7-13 summarizes the CSO EMCs for the baseline, pre-LTCP condition from 1985 to 2005. They were derived from site-specific EMCs, regulatory considerations (i.e., tributary strategy), and application of recommended EMCs (or constituent fractions) to fill data gaps.

Table 7-13. CSO water quality constituent EMC summary for Alexandria, Richmond, and Lynchburg, Virginia

	Water quality constituent (mg/L)[a]					
Member	**TN**	**NH_3-N**	**NO_2-N + NO_3-N**	**PO_4-P**	**TP**	**TSS**
Alexandria CSO	5.88	1.53	0.79	0.16 [b]	0.78	70.5
Richmond CSOs (Virginia Tributary Strategy)	8	1.4	1.1	0.2	1	130
Lynchburg[c] (Virginia Tributary Strategy)	8	1.4	1.1	0.2	1	130

a. Total organic nutrient forms can be derived by subtracting the inorganic forms from the total nutrient concentrations.

b. The Alexandria EMC for orthophosphate-P is estimated as 20% of TP as per the recommendations for filling these types of data gaps.

c. The Lynchburg EMCs correspond to the selected Richmond EMCs and the Virginia tributary strategy.

Second Round of CSO Characterization

The Environmental Protection Agency requested CSO service area data from 60 communities as part of a second round of characterization to provide supplementary information for a number of additional communities. From the request, 32 of the 60 communities submitted data in one form or another (e.g., hard copy data, ESRI shapefiles, PDF files, JPEG files, or KML files). Twenty-eight facilities did not respond or did not provide any usable data.

Data received from communities were digitized into ESRI shapefile format. Data that was received in shapefile format was reprojected (if needed) and merged with the *working* shapefile. Other data formats required a more intensive digitization process. KML files were merged and converted to ESRI shapefile format for subsequent inclusion in the master shapefile. Hard copies, JPEG images, and other date were manually digitized in the ESRI environment using a basemap *Service Area Delineations*.

Out of 60 communities, 28 did not provide service area information. In those cases, data for sewer service areas from USGS were used (circa 2000). The USGS spatial data also had to be delineated in cases where several overlapping service areas exist.

Once the CSO service areas were delineated, flow and load contributions from the areas were estimated. Rainfall data from a nearby climate station were obtained for each CSO community. To select a proximate climate station (the population of daily total rainfall stations, with a minimum percentage of completeness of data between 1985 and 2008, was used), a Thiessen polygon method was applied to assign the appropriate station to a given CSO community (Figure 7-11). Table 7-14 shows the assignment of the weather stations to the NPDES discharges.

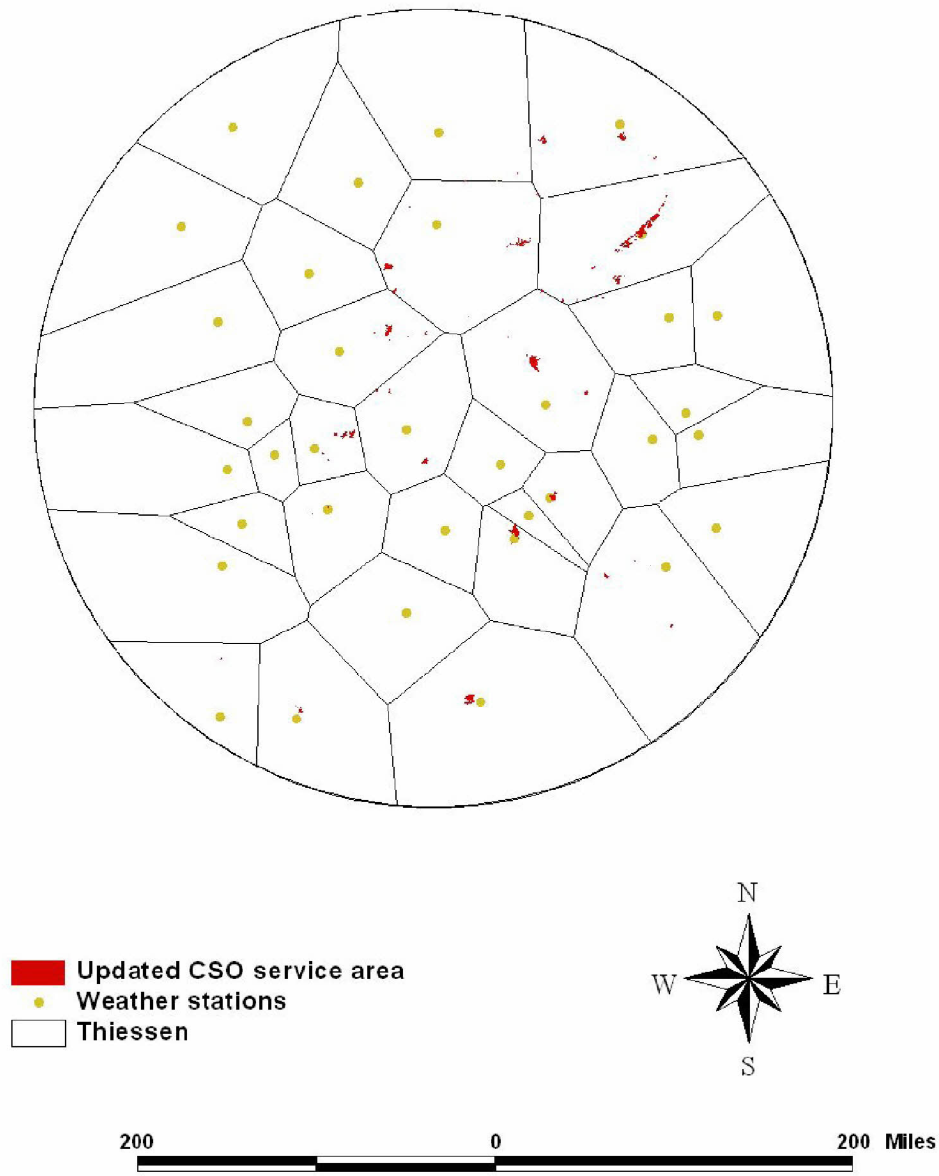


Figure 7-11. Theissen polygon method applied to daily rainfall stations.

Table 7-14. Weather stations assigned to CSO communities (by NPDES ID)

Weather stations-coop ID	NPDES ID	Weather stations-coop ID	NPDES ID
8906	DC0021199	9705	PA0026557
3570	DE0020265	9933	PA0026743
3570	MD0020249	9705	PA0026921
3570	MD0021571	0132	PA0027014
8065	MD0021598	0132	PA0027022
0465	MD0021601	8469	PA0027049
3570	MD0021636	8469	PA0027057
3570	MD0022764	9705	PA0027065
8065	MD0067384	9705	PA0027081
8065	MD0067407	9705	PA0027090
8065	MD0067423	9933	PA0027197
8065	MD0067547	9705	PA0027324
0687	NY0023981	8469	PA0028631
0687	NY0024406	0132	PA0028673
0687	NY0035742	8469	PA0036820
9705	PA0020940	4030	PA0037711
9933	PA0021237	8469	PA0038920
0132	PA0021539	0132	PA0043273
9933	PA0021571	8469	PA0046159
8469	PA0021687	0106	PA0070041
9072	PA0021814	0106	PA0070386
4030	PA0022209	9705	PAG062202
9705	PA0023248	9933	PAG063501
0106	PA0023558	5120	VA0024970
0687	PA0023736	8906	VA0025160
0687	PA0024341	7285	VA0025542
9705	PA0024406	7201	VA0063177
9705	PA0026107	6163	WV0020150
0132	PA0026191	6163	WV0021792
8469	PA0026310	4030	WV0023167
9705	PA0026361	8065	WV0024392
9705	PA0026492	8065	WV0105279

Overflow data from 8 of the 60 communities were available. The data were regressed with rainfall data from the local precipitation stations to identify the relationship between rainfall and overflows. Table 7-15 shows the coefficient of determination (R^2) for each of the community comparisons with rainfall.

Table 7-15. R^2 of the developed linear regression using rainfalls and CSO discharges for NPDES

NPDES ID	R^2
MD0067407	0.6
PA0023558	0.85
PA0022209	3.00E-06
MD0021598	0.67
PA0026361	0.56
PA0070386	0.13
PA0070041	0.03
PA0026107	0.18

The data sets with R^2 values higher than 0.5 (MD0067407, PA0023558, MD0021598, and PA0026361) were selected for further analysis. CSO discharge data from those communities were divided by the corresponding community areas (described above) to calculate unit area flows (gallon/day-acre). Once flows were derived, correlations were sought between the unit-area flows and the associated rainfall data by generating a best fit line. The best fit line is shown in Figure 7-12.

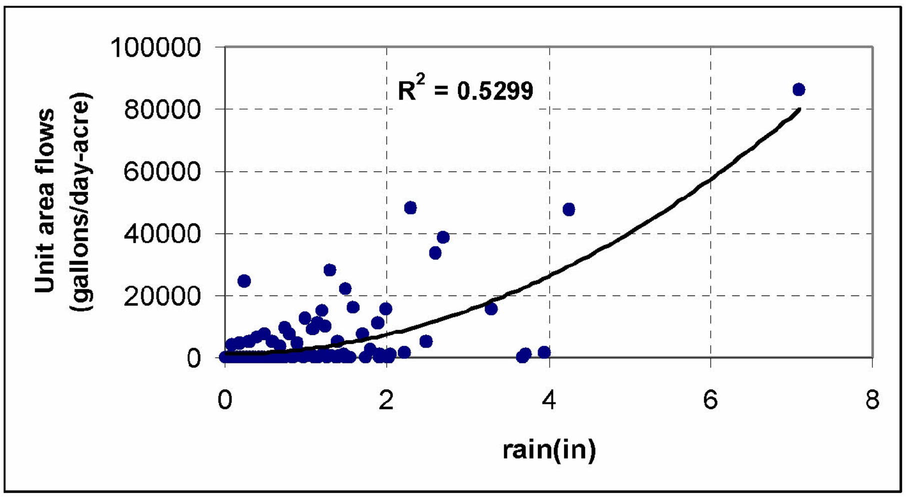


Figure 7-12. Best fit line; rainfall vs. unit area flow.

The best fit line suggests that smaller rainfall amounts produce small overflows. To address that issue, a cutoff rainfall rate was forced to explicitly eliminate the CSO events for small rainfalls. That rate was assigned on the basis of the lowest observed rainfall data generating an overflow at any of the four communities used to develop the best fit line. The best fit equation and the cutoff rate were then applied to the assigned rainfall data for each CSO community and results were multiplied by the community areas to generate the estimated CSO discharges for each community. Several communities' CSOs were taken offline during the 1985–2008 period, as identified during the data request effort. The communities' flows (and subsequent loads) were removed for offline periods. The flows for the second round of 60 communities are summed and displayed in Figure 7-13.

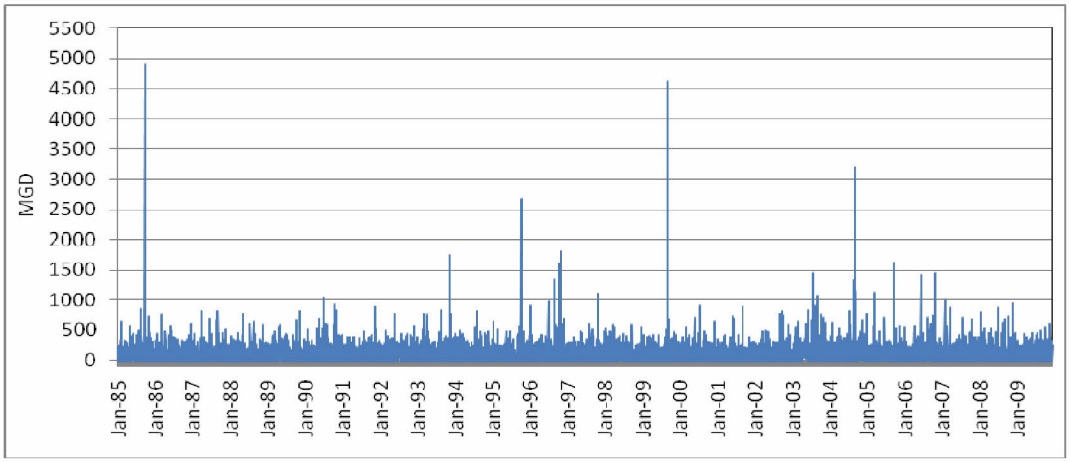


Figure 7-13. Summed CSO overflows for the second round of 60 communities, 1985–2009.

Water quality data were available for 3 of the 60 CSO communities, as shown in Table Table 7-16. The data were applied to the three communities at times of overflow (see above) to derive the loads.

Table 7-16. Averaged water quality data from CSO communities in the Chesapeake Bay watershed

NPDES ID	NH_3 (mg/L)	BOD_5 (mg/L)	TSS (mg/L)	TP (mg/L)	TKN (mg/L)	NO_2+NO_3 (mg/L)	TN (mg/L)	Nitrate as N(mg/L)	Phosphorus as P (mg/L)	Nitrite as N (mg/L)	NH_3 as N (mg/L)
MD0021598	1.324	26.620	84.960	0.437	4.324	1.552	5.876	--	--	--	--
PA0026361	--	24.219	96.418	--	--	--	--	1.433	0.629	0.088	--
PA0026107	--	52.249	143.547	3.179	--	--	--	0.866	--	0.601	3.778

* Parameter names were left as originally described in the original data sets.

To calculate loads for the remaining communities, national average values were used according to Novotny and Olem's (1994) nationwide average characteristics of CSOs (Table 7-17) were multiplied by the overflow for each community.

Table 7-17. Nationwide average characteristics of CSOs

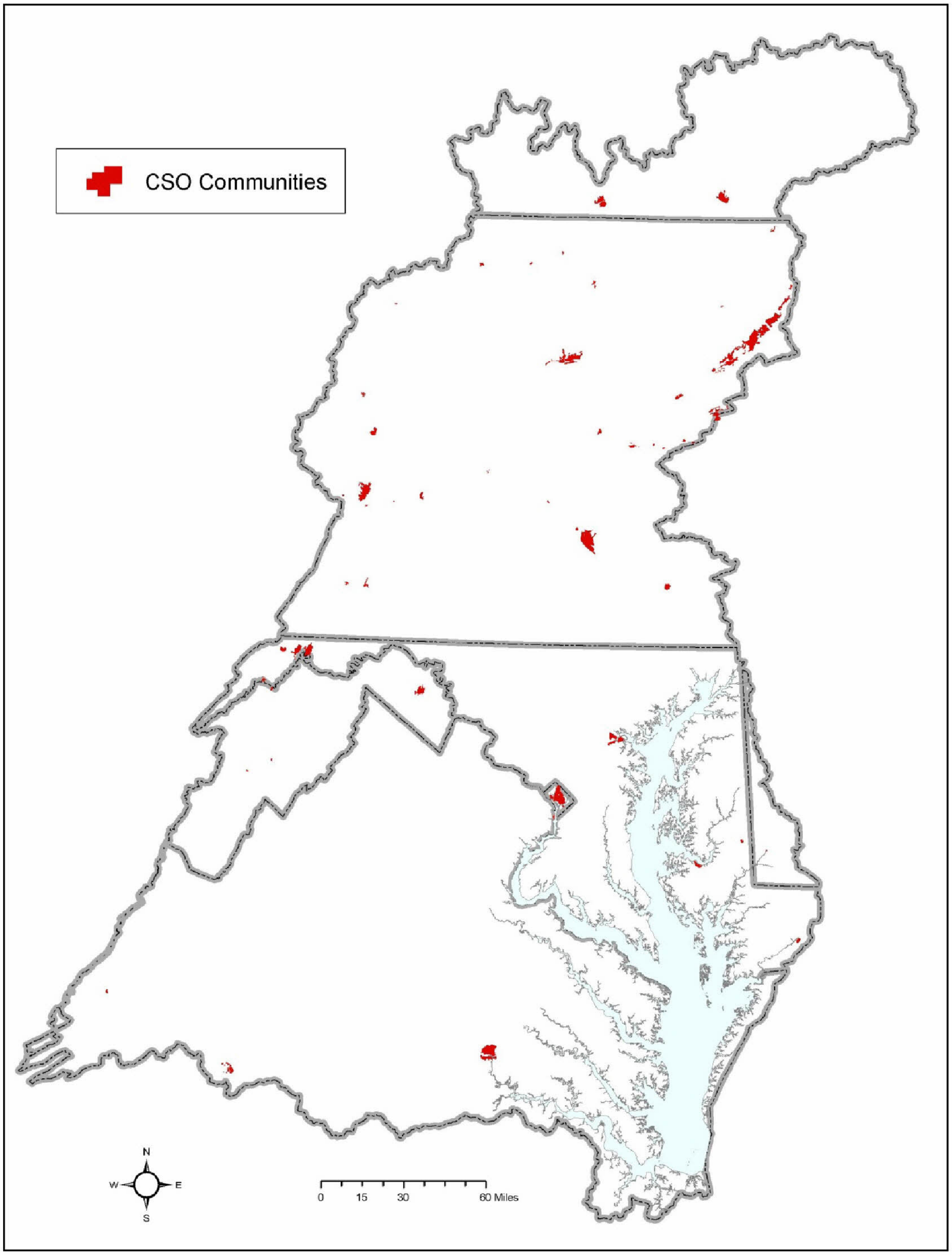
	BOD_5 (mg/L)	Suspended solids (mg/L)	TN (mg/L)	TP (mg/L)
Nationwide average characteristics of CSOs	115	370	9 to 10	1.9

Source: Novotony and Olem 1994

Table 7-18. Combined sewer system (CSS) communities in the Bay watershed

Jurisdiction	River basin	NPDES ID	Facility name
DC	Potomac	DC0021199	Washington, District of Columbia
DE	Eastern Shore	DE0020265	Seaford Waste Treatment Plant
MD	Eastern Shore	MD0020249	Federalsburg WWTP
MD	Eastern Shore	MD0021571	City of Salisbury WWTP
MD	Potomac	MD0021598	Cumberland WWTP
MD	Patapsco	MD0021601	Patapsco WWTP
MD	Eastern Shore	MD0021636	Cambridge WWTP
MD	Eastern Shore	MD0022764	Snow Hill W & S Dept.
MD	Potomac	MD0067384	Westernport CSO
MD	Potomac	MD0067407	Allegany County CSO
MD	Potomac	MD0067423	Frostburg CSO
MD	Potomac	MD0067547	Lavale Sanitary Commission CSO
NY	Susquehanna	NY0023981	Johnson City (V) Overflows
NY	Susquehanna	NY0024406	Binghamton (C) CSO
NY	Susquehanna	NY0035742	Chemung Co Elmira SD STP
PA	Susquehanna	PA0020940	Tunkhannock Boro Mun. Auth.
PA	Susquehanna	PA0021237	Newport Boro STP
PA	Susquehanna	PA0021539	Williamsburg Municipal Auth.
PA	Susquehanna	PA0021571	Marysville Borough WWTP
PA	Susquehanna	PA0021687	Wellsboro WWTP
PA	Susquehanna	PA0021814	Mansfield Boro WWTP
PA	Susquehanna	PA0022209	Bedford WWTP
PA	Susquehanna	PA0023248	Berwick Area Joint Sewer Auth. WWTP
PA	Susquehanna	PA0023558	Ashland WWTP
PA	Susquehanna	PA0023736	Tri-Boro Municipal Authority WWTP
PA	Susquehanna	PA0024341	Canton Boro Auth. WWTP
PA	Susquehanna	PA0024406	Mount Carmel WWTF
PA	Susquehanna	PA0026107	Wyoming Valley Sanitary Authority WWTP
PA	Susquehanna	PA0026191	Huntingdon Borough WWTF
PA	Susquehanna	PA0026310	Clearfield Mun. Auth. WWTP
PA	Susquehanna	PA0026361	Lower Lackawanna Valley San. Auth. WWTP
PA	Susquehanna	PA0026492	Scranton Sewer Authority WWTP
PA	Susquehanna	PA0026557	Sunbury City Mun. Auth. WWTP
PA	Susquehanna	PA0026743	Lancaster City WWTP
PA	Susquehanna	PA0026921	Greater Hazelton Joint Sewer Authority WWTP
PA	Susquehanna	PA0027014	Altoona City Auth. - Easterly WWTP
PA	Susquehanna	PA0027022	Altoona City Auth. - Westerly WWTF
PA	Susquehanna	PA0027049	Williamsport Sanitary Authority – West Plant
PA	Susquehanna	PA0027057	Williamsport Sanitary Authority – Central Plant
PA	Susquehanna	PA0027065	LRBSA - Archbald WWTP
PA	Susquehanna	PA0027081	LRBSA - Clinton WWTP
PA	Susquehanna	PA0027090	LRBSA - Throop WWTP

Jurisdiction	River basin	NPDES ID	Facility name
PA	Susquehanna	PA0027197	Harrisburg Advanced WWTF
PA	Susquehanna	PA0027324	Shamokin Coal Twp Joint Sewer Auth.
PA	Susquehanna	PA0028631	Mid-Cameron Authority
PA	Susquehanna	PA0028673	Gallitzin Borough Sew and Disp. Auth.
PA	Susquehanna	PA0036820	Galeton Borough Authority WWTP
PA	Susquehanna	PA0037711	Everett Area WWTP
PA	Susquehanna	PA0038920	Burnham Borough Authority WWTP
PA	Susquehanna	PA0043273	Hollidaysburg STP
PA	Susquehanna	PA0046159	Houtzdale Boro Municipal Sewer Authority
PA	Susquehanna	PA0070041	Mahanoy City Sewer Auth. WTP
PA	Susquehanna	PA0070386	Shenandoah Mun. Sewer Auth. WWTP
PA	Susquehanna	PAG062202	Lackawanna River Basin Sewer Auth.
PA	Susquehanna	PAG063501	Steelton Boro Authority
VA	James	VA0063177	Richmond
VA	James	VA0024970	Lynchburg
VA	James	VA0025542	Covington Sewage Treatment Plant
VA	Potomac	VA0087068	Alexandria
WV	Potomac	WV0020150	City of Moorefield
WV	Potomac	WV0021792	City of Petersburg
WV	Potomac	WV0023167	City of Martinsburg
WV	Potomac	WV0024392	City of Keyser
WV	Potomac	WV0105279	City of Piedmont



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 7-14. CSO communities in the Chesapeake Bay watershed.

7.2.7 Sanitary Sewer Overflows (SSOs)

Properly designed, operated, and maintained sanitary sewer systems are meant to collect and transport all the sewage that flows into them to a POTW. SSOs are illegal discharges of raw sewage from municipal sanitary sewer systems. Frequent SSOs are indicative of problems with a community's collection system and can be due to multiple factors:

- Infiltration and inflow contributes to SSOs when rainfall or snowmelt infiltrates through the ground into leaky sanitary sewers or when excess water flows in through roof drains connected to sewers, broken pipes, or badly connected sewer service lines. Poor service connections between sewer lines and building service lines can contribute as much as 60 percent of SSOs in some areas.
- Undersized systems contribute to SSOs when sewers and pumps are too small to carry sewage from newly developed subdivisions or commercial areas.
- Pipe failures contribute to SSOs as a result of blocked, broken, or cracked pipes; tree roots growing into the sewer; sections of pipe settling or shifting so that pipe joints no longer match; and sediment and other material building up causing pipes to break or collapse.
- Equipment failures contribute to SSOs because of pump failures or power failures.

SSOs represent a source of nutrients to the Chesapeake Bay; however, information available to characterize their contribution to the overall nutrient loads delivered to the Bay is limited largely because of their illegality and infrequency. Although the Phase 5.3 Model does not specifically account for SSOs, the nutrient load contributions from SSOs are part of the background conditions incorporated into the Phase 5.3 Watershed Model. Therefore, SSO loads are accounted for in the data used for calibration of the model.

7.3 Water Withdrawals

Water-use information for the Phase 5.3 Model domain has been assembled for simulating withdrawals from respective streams in the different river segments. Daily withdrawals are estimated on the basis of reported monthly values in some states or annual values estimated at 5-year intervals in others.

The nature of the water-use information depends on the water-use program of the state providing the information. For Maryland and Virginia, information consists of values reported by individual users along with the latitude and longitude of the withdrawal. In general, data reported for individual users is expected to be more accurate than estimated values. For New York, Pennsylvania, West Virginia, and North Carolina, water-use information for 1985, 1990, and 1995 was estimated by various techniques and aggregated by eight-digit hydrologic unit codes (HUCs), although better latitude and longitude information was available for consumptive use by thermoelectric withdrawals. Information for the year 2000 were estimated similarly but are aggregated by county.

The complete time series of water withdrawals as applied in the Phase 5.3 river-segments from 1985 to 2005 are in the Chesapeake Community Modeling Program's (CCMP) Phase 5.3 data library at:
http://ches.communitymodeling.org/models/CBPhase5/datalibrary.php.

7.3.1 Types and Timing of Water Withdrawals

Withdrawal information was grouped as irrigation use, thermoelectric use, or all other combined uses. Irrigation use is a separate category because of its extreme seasonal cycles. Thermoelectric use is a separate category because individual withdrawals commonly can be many millions of gallons per day, although in once-through thermoelectric cooling, most of the water is discharged back to the source water close to the withdrawal point. A part of the water, however, evaporates, resulting in a consumptive use that can be a significant net withdrawal from a stream.

Withdrawal information was derived from either monthly (Virginia), or annually reported values (Maryland), or from annual values estimated at 5-year intervals (New York, Pennsylvania, West Virginia, and North Carolina). The availability and accuracy of irrigation use information varies by state and by year. Maryland is the only state with reported irrigation data. In the early 1990s, Maryland passed laws, which were first implemented in 1995, requiring reporting irrigation.

The accuracy of the 5-year values used in most states have a higher uncertainty because estimates were derived from procedures selected from the national water-use program, which does not necessarily pertain to a Chesapeake watershed state, but they are the best available water withdraw information for much of the Chesapeake watershed.

Withdrawals for many water-use categories vary appreciably by season. Such variations can affect streamflow substantially because many uses are greater during the summer when streamflow approaches annual lows. For example, withdrawals for public water supply typically vary seasonally. For public supplies that provide water primarily for domestic use, withdrawals typically are greatest during the summer because of lawn irrigation, car washing, and similar activities. Peak daily use can be 180 percent of the average annual use (Clark et al. 1971) with the pattern of use largely controlled by temperature and precipitation. For suppliers that provide large water volumes to other users such as industrial users, other seasonal cycles can be superimposed on this cycle. Seasonal cycles in water use other than irrigation, however, remain uncertain and are not estimated.

Irrigation typically occurs during the growing season and increases when evaporation and plant transpiration (evapotranspiration) are high and precipitation is low. The seasonal effects are accounted for by the reported data of Maryland and Virginia but not in the estimated values of the other states. The timing of irrigation varies by crop but typically occurs during summer months. Much of the cropland in the watershed is planted in corn, soybeans, and small grains. Corn typically is planted early in the growing season (May) when evapotranspiration is at moderate levels. The corn typically matures and is no longer irrigated by the end of July. In contrast, soybeans are not planted until later in the growing season and mature in October. Small grains are typically planted in the fall and have little irrigation need. Using those assumptions, the estimated total annual irrigation use was distributed from May through October. Estimated values are daily values averaged over the entire year. The values were multiplied by 12 to give daily values if averaged over a month, and then the values were multiplied by the following fractions to account for the seasonal cycle: 0.1 (May), 0.175 (June), 0.225 (July), 0.225 (August), 0.175 (September), 0.1 (October) and 0.0 (November through April). If more geographically specific distributions are identified for parts of the watershed, those factors can be modified to better simulate actual conditions.

7.3.2 Consumptive Use

Consumptive use of surface waters is that part of the water that is consumed in manufacturing production or lost by evaporation and, therefore, not returned to streams. For many large uses, such as cooling water for condensers in thermoelectric generation, little water is consumed, and most is returned directly to the streams through permitted wastewater discharges.

Water supply withdraws are a special case of consumptive use. Municipal point source discharges are modeled as flow and load inputs to the appropriate stream segments. Such discharges can be to different streams or different stream segments than those from which the water was withdrawn. Consequently, water supply withdraws are modeled as if it were 100 percent consumptive use, with the wastewater modeled separately as return flow through a point source discharge. The net difference between the withdrawal and the discharge is the estimated actual consumptive use. Water-use categories for which the water primarily is returned to streams as permitted discharges include public supply, industrial use, and mining.

Solley et al. (1998) indicate that agricultural irrigation results in 60 percent to 100 percent consumptive use of the water withdraw, but the value is likely to be closer to 100 percent consumptive use throughout the modeled area because either spray or trickle irrigation are used, and neither method returns significant amounts of water to streams. Consumptive use by thermoelectric power withdraws are assumed to be 1 percent of the total withdraw because of evaporation before the water is returned to the river.

New York, Pennsylvania, and West Virginia

Water-use information for these states was limited to annual estimates from the 5-year compilations by HUC (1985, 1990, and 1995) or by county (2000). Locations for specific withdrawal points were unavailable for any uses except for thermoelectric uses in New York and Pennsylvania. The locations of other withdrawals were determined from maps of the counties, HUCs, cities, and towns. For counties and HUCs having large cities or towns, the withdrawal was assigned to the watershed at the upper end of the city because water-supply withdrawals typically are at the upstream end of a city to reduce the potential for contamination of the supply. For counties and HUCs having small withdrawals because they have no large towns, the withdrawals were assigned to the watershed at the lower end of the county or HUC. In places where boundaries for HUCs and counties do not coincide, the combination of use for the HUCs and counties was compared to help refine the watershed assignment. For example, if a county having substantial use was part of two HUCs and the use was high in one HUC and low in the other, the water use for the county was assigned to a watershed in the part of the county in the HUC having the high rate of use. Because the information consists of annual estimates at 5-year intervals, the withdrawals for the intervening years were determined by linear interpolation between years having information.

Maryland

Water-use data for Maryland are reported as daily values averaged for the year. Those average values are used for every day in that year. Water-use information for Maryland is otherwise processed as indicated above for all states.

Delaware

For the simulated river reaches in Delaware flowing to the Chesapeake, all of which are in the upper reaches of East Shore rivers, diversions are from groundwater only, and withdraws from these rivers are absent. The model has three Delaware reaches flowing to the Atlantic without water diversions because of an oversight in data collection—an oversight that will be corrected in future water-diversion databases as Phase 5.3 is expanded beyond the 2005 simulation period.

Virginia

Water-use data for Virginia are reported daily values averaged for each month. The average values are used for every day of the respective month. Water-use information for Virginia is otherwise processed as indicated above for all states.

North Carolina

Water-use information for North Carolina is limited to annual estimates from the 5-year compilations by HUC (1985, 1990, and 1995) and county (2000). Localities in North Carolina have developed water-supply plans that are on the webpage for the North Carolina Department of Environment and Natural Resources. The supply plans give the locations of individual withdrawals so that the appropriate watershed could be assigned to the withdrawals. The plans are for 1997 and 1992 and include water-use values. The water-use values were used as a part of the information and were used to determine ratios among the multiple withdrawals for counties and HUC having multiple withdrawals. Such ratios were applied to the 5-year estimates to provide estimates of use for each withdrawal. Because the information consists of annual estimates at 5-year intervals, the withdrawals for the intervening years were determined by linear interpolation.

7.3.3 DC Water Supply and Treatment

The District of Columbia metropolitan region's drinking water supply is the largest consumptive water withdrawal in the Chesapeake watershed. Water treatment consists of withdraw of Potomac River water just above the fall line at Great Falls to the Dalecarlia Reservoir, which acts as a presedimentation basin before final treatment at the Dalecarlia or McMillan water treatment plants (DCWASA 2006). The withdrawals at Great Falls are about 5 percent of the average Potomac flow.

The Washington water treatment generates residual solids, a byproduct of producing drinking water, and periodically discharges the material to the Potomac River. The residuals consist of river sediment and solid materials generated by adding coagulant as part of the drinking water treatment process. Plans for treatment and land disposal of the Dalecarlia Reservoir sludge are underway, and a treatment system is expected to be fully operational in 2010.

Until 2010, the residual solids had been discharged to the Potomac River just above the Chain Bridge water quality monitoring station. The episodic discharge plume flows along the Maryland shore and is thought to be largely or entirely absent from the Chain Bridge water quality monitoring data.

Reflecting water treatment practices in the Washington metropolitan region before 2010, the sediment loads estimated from the Dalecarlia Reservoir NPDES records in the CBP point source database are returned to the Potomac reach just above the fall line (Chain Bridge monitoring station) as a daily load. To get the load of total phosphorus and particulate nitrogen associated with the Dalecarlia Reservoir discharged sediment but unreported in the NPDES record, a regression was formed between total suspended solids (TSS) and total phosphorus (TP) and particulate nitrogen (PN) as observed at the Chain Bridge station. That provides a representation of the associated load of phosphorus and particulate nitrogen that would be taken into the Dalecarlia Reservoir presedimentation basin and ultimately associated with the sediment discharged from Dalecarlia. The TSS concentration was found to be somewhat predictive of total phosphorus concentration at the Chain Bridge station with an R^2 of 0.72 and a low intercept. The weighted average load is 0.0015 mg TP/mg TSS. The TSS concentration was found to be moderately predictive of the particulate nitrogen concentration with an R^2 of 0.52, a relatively low intercept, and a weighted average load of particulate nitrogen (PN) of 0.007 mg PN/mg TSS. Based on Potomac observations, the particulate nitrogen is assumed to be 11 percent particulate ammonia and the remainder being particulate organic nitrogen.

The Dalecarlia Reservoir is associated with public water produced by the Washington Aqueduct. The Aqueduct supplies water to the District of Columbia and the Virginia Arlington and Fairfax counties. Using an average of the years 2007 to 2010, the District's share of the Washington Aqueduct supply is about 74 percent and Virginia's is 26 percent. However, regardless of the distribution of water supplies from the Washington Aqueduct, the attribution of the Dalecarlia Reservoir load is to the District of Columbia alone because of the physical location of the Dalecarlia Reservoir.

More importantly, in all management scenarios of 2010 and beyond, the loads of sediment and particulate nutrients from this source are assumed to be reduced on the order of about 99.5 percent because of changes in the operations of the Washington Aqueduct. The District is credited with the reduction in the load. That means that the load from the Dalecarlia Reservoir is in the Phase 5.3 calibration with loads on the order of about 18 million pounds of TSS and are in any management scenarios that are representative of the period before 2010, but the high load does not influence the Chesapeake TMDL allocation because the scenarios of the TMDL allocation are based on the year 2010. The TMDL allocation scenarios are described in detail in Section 12. By 2010 the total suspended solids loads from the Dalecarlia Reservoir were reduced to only about 90,000 pounds annually.

7.4 On-site Wastewater Disposal Systems (OSWDS)

On-site Wastewater Disposal Systems (OSWDS), commonly called septic systems, represent an estimated 6 percent of the total nitrogen load from the Chesapeake watershed in 2000 (Phase 4.3 Model—Base Scenario). Information of the loads from these systems are generally sparse. Detailed descriptions of data procedures, source information, and assumptions used in estimating the loads are in Palace et al. (1998).

Loads from OSWDS are compiled from census data using the methodology suggested in Maizel et al. (1995). OSWDS are simulated as a nitrate load discharged to the river. Phosphorus loads are assumed to be entirely attenuated by the OSWDS. The OSWDS loads are determined by assessing the census records of waste disposal systems associated with households. Standard engineering assumptions of per capita nitrogen waste and standard attenuation of nitrogen in the septic systems are applied. Overall, the assumption of a load of 4.0 kg/person-year is used at the edge of the OSWDS field, all in the form of nitrate (Metcalf and Eddy. 1979).

Using an average water flow of 75 gallons/person-day for a septic tank (Salvato 1982), a mean value of 3,940 grams/person-year for groundwater septic flow, 4,240 grams/person-year for surface flow of septic effluent, and typical surface/subsurface splits as reported by Maizel et al. (1995), a total nitrogen concentration of about 39 mg/L at the edge of the septic field was calculated. That concentration compares favorably with Salvato (1982) who calculated on-site wastewater management system total nitrogen concentrations of 36 mg/L. It is assumed that attenuation of the nitrate loads between the septic system field and the edge-of-river nitrate loads represented in the Phase 5.3 Model is due to (1) attenuation in anaerobic saturated soils with sufficient organic carbon (Robertson et al. 1991; Robertson and Cherry 1992), (2) attenuation by plant uptake (Brown and Thomas 1978), or (3) attenuation in low-order streams before the simulated river reach. Overall, the total attenuation is assumed to be 60 percent (Palace et al. 1998).

OSWDS loads are input as a daily load in the river reach. For coastal plain OSWDS loads where there is no simulated reach, the OSWDS nitrate loads are delivered directly to the tidal Bay.

Two potential sources of error are in the estimate of nitrogen loads from septic systems. After 1990, the U.S. Census Bureau survey no longer enumerates the number of household served by septic systems. The fraction of the population on septic systems and the number of people per system are based on the 1990 Census estimates and are therefore unable to be updated through the 1985 to 2005 simulation period of Phase 5.3. The fraction of the population on septic and the number of people per system as used in the Phase 5.3 Model, therefore, do not change over the simulation period. The assumption of a 60 percent attenuation between the septic field and the edge-of-river for nitrogen loads applied over the entire Bay watershed could also introduce errors in the estimation of septic loads.

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